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A STUDY CONCERNING THE EFFECT OF AN AURAL INCREMENT IN PROGRAMED AUTOINSTRUCTIONAL MATHEMATICAL MATERIAL FOR COLLEGE STUDENTS.

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EXPERIMENTAL PROGRAMED INSTRUCTIONAL MATERIALS IN MATHEMATICS WERE DEVELOPED FOR THE USE OF COLLEGE STUDENTS. THE PROGRAMED UNIT WAS PRESENTED BY THREE ALTERNATIVE METHODS - READING ONLY, READING AND AURAL, AND ALMOST COMPLETELY AURAL. THE SUBJECTS CONSISTED OF 92 STUDENTS RANDOMLY ASSIGNED TO 1 OF THE 3 METHODS. PRETESTS WERE ADMINISTERED TO DETERMINE THE ACHIEVEMENT LEVELS OF THE SUBJECTS. CRITERION TESTS WERE ADMINISTERED TO EACH SUBJECT AND AN ATTITUDE QUESTIONNAIRE WAS ALSO ADMINISTERED TO DETERMINE STUDENT RESPONSE. RESULTS INDICATED THAT THE THREE GROUPS DID DIFFER SIGNIFICANTLY. FURTHER RESEARCH WAS SUGGESTED FOR EXTERNALLY-PACED CONDITIONS AND SELF-PACED CONDITIONS FOR AUDIOPROGRAMED MATERIAL. (RS)

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The author wishes to dedicate this dissertation to the memory of her husband, Jesse, and to their son, David, who, she hopes, will enjoy mathematics as much as his parents have.

TABLE OF CONTENTS

Page

ACKNOWLEDGEMENTS ii

LIST OF TABLES vi

Chapter

I. BACKGROUND TO THE STUDY 1

Introduction
Purpose
Related Research

II. DEVELOPMENT OF THE PROGRAMED TEXT AND OTHER MATERIALS USED IN THE EXPERIMENT 6

Selection of the Topic
Writing of the First Draft
Writing of the Final Program
The Two Audio-complemented Versions of the Program
Preparation of the Audio Tapes
Preparation of the Attitude Questionnaire

III. DESCRIPTION OF THE STUDY 19

Introduction
Experimental Design
Subjects
The Pretest
Randomization of Subjects
Tests Given to Determine Interacting Factors
Other Controls
Description of the Population and of the Sample
The Experiment

IV. ANALYSIS OF DATA 32

Criterion Tests
Analysis of the Effect of the Covariants of Listening Comprehension and Reading Level . . .
Correlation of Criterion Scores with Listening Comprehension Scores and with Reading Level Scores . .
Attitude Questionnaire

Chapter

V. CONCLUSIONS AND RECOMMENDATIONS 47

Conclusions
Recommendations

Appendix

A. RAW DATA 52

B. GRAPHS 56

C. PRETEST 64

D. LETTER AND SCHEDULE 68

E. INSTRUCTIONS 73

F. ATTITUDE QUESTIONNAIRE 76

G. INCIDENCE OF RESPONSES TO EACH QUESTION OF THE ATTITUDE QUESTIONNAIRE 82

H. UNSOLICITED COMMENTS ON THE ATTITUDE QUESTIONNAIRE 87

I. CRITERION TESTS 89

J. THE PROGRAMED TEXTS 104

K. THEORY OF OPERATION AND SCHEMATIC DIAGRAMS OF THE ADAPTER AND OF THE DESK CONTROL BOX 560

REFERENCES 565

LIST OF TABLES

Table		Page
1.	Times Required for the Initial Pretesting of the Program	9
2.	Times and Scores of Three Students who Tested the Final Draft of the Program	15
3.	Times of the Audio Tapes	18
4.	Percentile Bands for Certain SCAT Raw Scores	24
5.	Definition of Ability Levels	25
6.	Characteristics of the Sample with respect to Age, Sex, and Class	28
7.	Means, Standard Deviations, and Sample Sizes of the Cells	33
8.	Analysis of Variance of Test Scores for Each of the Chapters and for the Total	34
9.	Summary of Tests for Homogeneity of Variance	36
10.	Analysis of Covariance of Total Test Scores Adjusted with respect to Listening Comprehension for Each Ability Level	37
11.	Analysis of Covariance of Total Test Scores Adjusted with respect to Reading Level for Each Ability Level	38
12.	Means, and Adjusted Means, of the Deviations from the Mean of the Total Test Scores	38
13.	Correlations of Total Test Scores with Listening and with Reading Scores	39
14.	The Wilcoxon Rank Sum Test Analysis of Attitude Questionnaire Scores	41
15.	The Wilcoxon Rank Sum Test Analysis of the Variability of Attitude Questionnaire Scores	42

Table Page

16. The Wilcoxon Rank Sum Test Analysis of Attitude Questionnaire Scores at Each Ability Level 42

17. The Wilcoxon Rank Sum Test Analysis of the Variability of Attitude Questionnaire Scores at Each Ability Level . . . 43

18. Means of Attitude Questionnaire Scores 45

19. Raw Data 53

20. Incidence of Responses to Each Question of the Attitude Questionnaire 83

CHAPTER I

BACKGROUND TO THE STUDY

Introduction

Programed instruction is one of the most recent tools made available to educators. It was given its impetus in 1954 by the research and writings of Dr. B. F. Skinner. Although in the intervening years many other types of auto-instructional materials--e. g., programs involving branching, scrambled programs, and hybrid programs--have been developed and proved equally effective, the majority of programs in use today have the characteristics of those developed by Dr. Skinner [15]. Such a program, usually called a linear program, may be described as one which has a uniquely ordered sequence of stimulus items concluding with a brief question or an incomplete sentence, requires the student to choose, or to construct, an appropriate response, imparts to the student immediate knowledge of the correctness of his response, reinforces each correct response, enables the student to move at his own pace by small steps from what he knows to whatever behavior he is supposed to be able to demonstrate at the conclusion of his study, and allows the student to make very few errors.

Prior to this study the use of aural stimulation in programed auto-instructional mathematical materials had not been investigated. No information concerning the contribution that sound could make to the

effectiveness of such material was available. The need for research in this area was pointed out by C. R. Carpenter [2].

The metamorphosis through which programed instruction has passed in the last decade is in no sense completed. Much has been learned about the various ways a program can be constructed to enable the student to learn. However, there are still many recognized limitations of programed auto-instructional material today:

1. Because of the verbal nature of most programs, the student who possesses a high verbal ability and who comprehends what he reads quickly and easily has a great advantage when he avails himself of programed auto-instructional material [15, 3]. The student who does not have this facility may become frustrated by a program requiring a great deal of reading.

2. Often the average student does not develop the ability to communicate orally about the subject he is studying. Sometimes, for example, gross mistakes occur in the pronunciation of technical words. (This was observed by Heimer and Lottes in interviews with students participating in their experiments at The Pennsylvania State University [11--I, II] and related to the author orally. This was also registered as a complaint by the students participating in a subsequent study by Dick at the same university [11--IV].)

3. Another criticism of programed texts is that they are too sterile--too impersonal. They fail to arouse enthusiasm for the subject being studied. Often a student is neither inspired nor motivated to think more deeply about the subject being studied [15, 3, 14].

4. A student quickly becomes tired of the monotony of single stimulus instructional material [14]. Specialists in audio-visual education decry the lack of audio-visual content in the frames of the program [18].

5. A student is often discouraged by the sheer bulk of a program before he even begins it [12].

Robert E. Stake gives the following advice: ". . . The programer should . . . be concerned about awakening creativity and developing evaluative abilities. He should flavor his program with idealism or

pragmatism, the humor, the digression, the provocativeness that are characteristic of ideal tutors. These are facets that not only make things more interesting, but cultivate an involvement in thinking as well as in overt responding" [17, p. 248].

It was hypothesized that, by the use of an aural increment in programed auto-instructional material, each of the above weaknesses could in some degree be alleviated and some of the characteristics mentioned by Mr. Stake incorporated. No longer should the poor reader be at so great a disadvantage; help could be given towards correct pronunciation; humor, gentle prodding, anecdotes, historical references, etc., should help keep the student from becoming bored and should cause him to feel less as a "responding machine" [14] and more as the individual person he is. Also the stimulation of two senses, visual and aural, simultaneously, should create a more favorable instructional climate. An audio-supplemented programed text should more nearly simulate the person-to-person relationship between the teacher and the student than would a programed text alone.

Purpose

It was the purpose of this study to investigate the effect of an aural increment in programed auto-instructional mathematical material for college students. To accomplish this the author prepared a programed unit of the Skinnerian type on a topic in modern mathematics designed for students enrolled in a course entitled "Basic Mathematics for General Education." Two other versions of this programed unit and two sets of audio tapes to be used with these versions were also prepared. The topic chosen for this unit was "Systems of Numeration."

The effect of an aural increment in programed auto-instructional mathematical materials was investigated by comparing the relative effectiveness of three instructional methods:

1. The programed unit was presented visually--i. e., the student studied the program by reading it.
2. The programed unit was presented partly aurally and partly visually--i. e., the student studied the program by listening to part of it and by reading part of it. Only when a new rule or algorithm was presented were both reading and listening employed simultaneously.
3. The programed unit was presented almost completely aurally --i. e., the student studied the program by listening to most of it and by reading only enough to master notation and form.

Related Research

The use of audio in connection with programed methods had been, until now, confined largely to instruction of a linguistic or a directive nature--i. e., in articulation and sound discrimination in speech therapy or in music education [5, 16], in teaching foreign languages [13], in giving manipulative directions for industrial processes (for example, in the "High Achievement Program in Methods-time Measurement," published by the Maynard Research Council, Inc., Pittsburgh, Pennsylvania, for use with the Graflex Audio Graphic), and in directing a student in his laboratory work [10].

Since this experiment was conducted, it has come to the attention of the author that ICS/Educasting Systems, in conjunction with TuTorTape Laboratories, has produced some programed tapes. The presentation of these is quite complex; it employs a four-track teaching tape and a "four-channel modulator which is circuited to the FM transmitter" [8]. Each participant must also have a specially adapted FM receiver "equipped

with four tuning push buttons which control the filter circuits, and which may be alternately incorporated in the broadband of the FM detector circuits" [8]. After receiving the instruction aurally, the student is given, also aurally, a choice of four possible responses from which he is to choose the correct one. He makes this choice by pressing any one of the four buttons. If he chooses the correct response, it is reinforced; if he does not, he is told why his response was wrong, is given the correct answer, and proceeds to the next step. It is also apparent that the only overt response required is that of pushing one of four different buttons--and even this is not completely demanded, for a student would still be "tuned in" to the last channel (button) he pushed if he should choose to remain idle and wait for the answer. No simultaneous reading is required although workbooks can be used to supplement the audio portion of the instruction. It seems that the student is also externally paced. Although these programed tapes are commercially produced for subscribing FM radio stations, the presentation of them is, now, very limited in its availability to the public. No data concerning research as to the effectiveness of this method with regard to learning are available at this time.

CHAPTER II

DEVELOPMENT OF THE PROGRAMED TEXT AND OTHER MATERIALS USED IN THE EXPERIMENT

Selection of the Topic

The selection of the topic, "Systems of Numeration," was, in large measure, influenced by three factors.

1. The topic should be one which was to be taught in the course "Basic Mathematics for General Education."
2. The topic should be adaptable to programing techniques.
3. The topic should be one which was not readily available in programed form.

Writing of the First Draft

Because the program had to be written so that it could be adapted to each of the three instructional methods, it was decided that the linear programing technique was most appropriate for the writing of this program. Because the subjects in two of the instructional methods would study as a group, it was not possible to incorporate the technique of branching in this program. Frames to challenge the student to generalize and to think independently were included in the program whenever possible.

The first draft contained five chapters which were as follows:

Chapter One.-- The Importance of Place Value, the Process of Writing Consecutive Numerals in Various Numeration Systems, and the

Finding of Decimal Numerals Equivalent to Numerals in Bases other than Base Ten.

Chapter Two.--The Finding of Numerals in Bases other than Base Ten Equivalent to Decimal Numerals and the Comparison of Numbers Represented by Numerals in Various Bases.

Chapter Three.--Addition and Subtraction in Various Numeration Systems.

Chapter Four.--Multiplication and Division in Various Numeration Systems.

Chapter Five.--The Finding of Equivalent Numerals in Various Bases, without Reference to the Decimal System.

Chapter One contained 47 frames; Chapter Two, 23 frames; Chapter Three, 35 frames; Chapter Four, 26 frames; Chapter Five, 25 frames. The first draft thus contained a total of 156 frames. A criterion test for each chapter was then devised.

The decimal numeration system, with which each student would be familiar, was used to introduce any new principle which the program endeavored to teach. In most instances, the same principle was then demonstrated in the quinary numeration system, and a sufficient number of problems was given to enable the student to understand and be able to apply it. Problems involving every numeration system from the binary system through the duo-decimal system were presented in the program and the accompanying quizzes. Reference was also made to the ancient Mayan numeration system, which used a base of twenty.

The "grid" method was the pedagogical device used to teach the students how to perform the operations in the third and fourth chapters.

The chief audio-visual aid used throughout the program consisted of diagrams of various abaci. The author chose to represent an abacus for a given numeration system of base n as one having n beads on each rod, rather than n - 1 beads on each rod. This is historically sound and lends itself to easier explanation; it parallels the method of regrouping which is widely used in teaching children the meaning of place value as well as in teaching them how to perform the operations in the decimal system.

The program in this form was administered to a former second grade public school teacher. Realizing that this topic is now often taught in the elementary grades, she was interested in learning about numeration systems. The last mathematics she had studied was plane geometry in high school and she had no previous knowledge of numeration systems other than the decimal system. It should be noted, on the other hand, that she was exceptional in her ability to learn, having attained a nearly perfect quality point average, 2.9/3.0, on her undergraduate work, and having graduated from a reputable state college in the Midwest at the top of a class of approximately three hundred seventy-five students.

Over a period of five days the separate chapters were studied by this individual. A record of her responses to each frame was kept. Any frame in which the content was not clear, or in which the response was incorrect, was noted and subsequently revised. At the conclusion of her study of each chapter, the criterion test devised for that chapter was administered. The amount of time required for the study of each chapter and for the completion of the test is given in Table 1.

TABLE 1

TIMES (IN MINUTES) REQUIRED FOR THE INITIAL PRETESTING OF THE PROGRAM

Chapter	Time	Test Time	
One	63	20	
Two	38	45	
Three	65	45	(15, plus 30 used in checking work)
Four	50	45	(15, plus 30 used in checking work)
Five	45	45	(20, plus 25 used in checking work)

Writing of the Final Program

Upon consideration of the results obtained from the testing of the first draft, it was decided that the topic chosen, viz. "Systems of Numeration," should be arranged in eight separate chapters as follows:

Chapter One.--The Importance of Place Value and the Process of Writing Consecutive Numerals in Various Numeration Systems.

Chapter Two.--The Finding of Decimal Numerals Equivalent to Numerals in Bases other than Base Ten.

Chapter Three.--The Finding of Numerals in Bases other than Base Ten Equivalent to Decimal Numerals, and the Comparison of Numbers Represented by Numerals in Various Bases.

Chapter Four.--The Operation of Addition in Various Numeration Systems.

Chapter Five.--The Operation of Subtraction in Various Numeration Systems.

Chapter Six.--The Operation of Multiplication in Various Numeration Systems.

Chapter Seven.--The Operation of Division in Various Numeration Systems.

Chapter Eight.--The Finding of Equivalent Numerals in Various Bases, with and without Reference to the Decimal System.

The author felt that, for the average student who would be involved in the experiment, the material must be presented in smaller steps, and that more repetition would enhance the effectiveness of the program. Each chapter began with a review of the essential points taught in previous chapters and each chapter concluded with a summary of what the student should have learned in that chapter. The first major revision contained a total of 305 frames--45, 42, 42, 43, 35, 35, 34, and 29 frames for Chapters One through Eight, respectively.

The original cirterion tests were revised to correspond to the revision of the program.

The program in this form was administered to several individuals who had no previous knowledge of numeration systems other than the decimal system. Time was not available for any of these to complete all eight chapters. It was determined from these observations, however, that the early chapters were too time-consuming, as it was the intention that the amount of time required for the completion of each chapter and the accompanying test should be no longer than 55 minutes for the average student.

A rather inconsequential revision was made. The problems given in the frames of the chapters were simplified so that the greatest amount of the work on the part of the student was in developing concepts and obtaining skills rather than in doing laborious arithmetic. The number of frames remained the same.

The program was then taken by seven young people, including four girls and three boys, none of whom knew anything about numeration systems, other than the decimal system. Two of these (boys) were high school seniors, and the other five were recent high school graduates. The author observed each student as he or she studied the program and made necessary revisions after each one completed a chapter. No major revision occurred in Chapters One and Two. The average times required to complete these chapters and tests by the seven students were 45 minutes and 47 minutes for Chapters One and Two, respectively.

Chapter Three was taken by only six of these students because one girl became ill and was unable to complete the program. The average time required to complete this chapter and take the test by five of these students was 56 minutes. In order to shorten the length of time required for this chapter, the decision to omit the eleven frames on the comparison of numbers was made. The sixth student completed this chapter and the test in 39 minutes. The performances of these students on the criterion test for this chapter indicated that half of them confused the method taught in Chapter Three with that taught in Chapter Two. To remedy this problem it was decided that the subscript used with a numeral to indicate the numeration system to which it belonged should be spelled instead of being given as a Hindu-Arabic numeral, and "ten" should be placed in subscript position when a decimal numeral was indicated. This was a major revision which took place before the final program was tested.

In the next four chapters, dealing with the operations of addition, subtraction, multiplication, and division, the "grid" method was used as a pedagogical device. In each case, work with this method was introduced

in the familiar decimal system, addition and multiplication tables were worked out for the quinary numeration system, and problems were given which necessitated the use of these tables. In order to give the students more opportunity to compute in other numeration systems, the tables for the septenary numeration system were then given and a corresponding group of problems presented. (It was decided, however, to omit this section in each of the four chapters in order to reduce the length of time required to complete them. This resulted in a reduction of the program by 29 frames.) Work in the binary numeration system was then introduced. In this system the students were asked to remember the addition and multiplication tables. In each of the four chapters a summary frame, with the appropriate tables, involving computation in the ternary or the quaternary numeration system was given. Throughout the program emphasis was put on various methods for checking one's work.

The average time spent on Chapter Four and the corresponding test by the six students was 54 minutes (excluding time to check the tests). The results obtained by observing the tests were good. Again, some simplification of problems was done.

Due to other demands the two high school boys were not able to complete the eight chapters. Therefore, there were only five students who completed Chapter Five and four who completed Chapter Six. The average time required for Chapter Four was 61 minutes; the results of the tests were good. The average time required for Chapter Five was 56 minutes; again the tests reflected that the students understood this material. Because of the necessary departure of the author, the third boy was not able to finish the last two chapters.

The chapter on division proved to be a very difficult chapter. The average time spent on it by the three girls was 82 minutes. The results, as indicated by the criterion tests, were not good. It was obvious that, in the time alloted, division by a number named by a numeral consisting of more than one digit could not be taught. Consequently this chapter was greatly revised. Frames pertaining to division by a number represented by a numeral of two or more digits were deleted. The content of many of the remaining frames was rewritten and presented in smaller steps. More frames were introduced which presented problems in which the divisor was indicated by a one-digit numeral.

The material presented in Chapter Eight attempted to teach the method of finding equivalent numerals in any base in three different ways. It was first pointed out that a numeral in any base equivalent to a given numeral in another base could be found by using the methods of Chapters Two and Three--i. e., by finding the decimal numeral to which the given numeral is equivalent and then finding the numeral in the desired base equivalent to this decimal numeral. The method of grouping the digits in numerals, whose bases were related by powers, was also taught--e. g., since the bases of the binary and the quaternary numeration systems are related by powers ($2^2 = 4$), the quaternary numeral equivalent to a given binary numeral could be written immediately by using four basic relationships and grouping the digits of the binary numeral two at a time. The third way was to expand a given numeral, to write each numeral in the expansion in terms of the required base, and to multiply and add in this desired system. It was also noted that the method corresponding to that taught in Chapter Three was also possible

for the general case--i. e., repeated division, using division in the given base and writing the remainders in the desired base. The criterion test for this chapter served as a cumulative test over the eight chapters.

The average time required for this last chapter and test was 55 minutes. The results, as revealed by the performances of the students on the test, were satisfactory; again it was evident that the operation of division had not been mastered. To reduce the amount of time required for this chapter, it was decided that only the first two methods should be presented in this chapter and that the generalizations of the methods of the second and third chapters would only be mentioned. As a result of this decision, it seemed more logical that this chapter should precede the chapters on operations; and, therefore, it was placed there in the final revision.

Because of the necessity of giving two standardized tests (which will be discussed in the following chapter) and the restricted amount of time available on the part of the subjects, the chapters on subtraction and division were omitted in the final version of the program.

In its final version, the program (Appendix J) consisted of the following six chapters:

Chapter One.--The Importance of Place Value and the Process of Writing Consecutive Numerals in Various Numeration Systems.

Chapter Two.--The Finding of Decimal Numerals Equivalent to Numerals in Bases other than Base Ten.

Chapter Three.--The Finding of Numerals in Bases other than Base Ten Equivalent to Decimal Numerals.

Chapter Four.--The Finding of Equivalent Numerals in Various Numeration Systems, with and without Reference to the Decimal System.

Chapter Five.--The Operation of Addition in Various Numeration Systems.

Chapter Six.--The Operation of Multiplication in Various Numeration Systems.

The criterion tests were also revised, and approximately doubled in length, in order to obtain more spread of scores. The test for Chapter Six now served as the comprehensive test. (These tests are found in Appendix I.)

Thus this final version of the program, in typewritten form, and the accompanying criterion tests were used with three students for the purpose of final testing. These students, although enrolled in a first semester course of calculus, had no previous knowledge of numeration systems other than the decimal system.

The results obtained from this testing were good and it was felt that no further revision was necessary. The times and scores of each of these individuals are summarized in Table 2.

TABLE 2

TIMES AND SCORES OF THREE STUDENTS WHO TESTED THE FINAL DRAFT OF THE PROGRAM

Chapter	Minutes required for the program			Minutes required for the test			Test score		
	Student								
	A	B	C	A	B	C	A	B	C
One	20	48	45	6	7	4	100	94	100
Two	35	58	44	7	5	5	92	88	92
Three	34	37	38	12	5	12	100	80	89
Four	30	41	22	5	13	21	90	97	82
Five	45	60	41	6	8	5	98	100	100
Six	42	52	31	17	18	11	100	91	97

The Two Audio-complemented Versions of the Program

Some care was taken in writing the program to phrase the sentences in each frame so that the blank, or blanks, to be completed occurred at the end of a sentence. Hence, the writing of the other two versions of the program was easily accomplished. Very few adjustments had to be made.

In the second version of the programed booklet, important rules, or algorithms, were stated. All drawings which appeared in the original version, problems illustrating notation and form, and the question to be answered or the sentence to be completed, were given in the second version of the programed booklet. Accompanying tapes were prepared for each chapter. These tapes presented aurally all the content of the frames in the original version which did not appear in the second version of the programed booklet. The rules and algorithms were given aurally, too.

In the third version of the programed booklet, only the drawings which appeared in the original version and the problems illustrating notation and form were presented. Blanks were provided for the responses of the student. So that no student would be penalized by not recording a problem correctly, problems were given symbolically in the programed booklet. Accompanying tapes were prepared for each chapter. These tapes presented aurally all the content of the frames in the original version which did not appear in the third version of the programed booklet. Problems, questions, and sentences to be completed were presented aurally. The rules, or algorithms, were given aurally and immediately repeated for emphasis.

The three versions of the program constitute Appendix J. The original version is presented in the top left position; the second

version, in the bottom left position; the third version, in the top right position. The answer, or reinforcement, to each frame was identical in each version and is given in the bottom right position.

Preparation of the Audio Tapes

The aural part of the program was presented to the subjects at the rate of 110 words per minute. This rate is in accord with the research of Cantril and Allport [1]. They determined the optimum rate for delivery of theoretical or abstract material to be from 110 to 130 words per minute, and the optimum rate for delivery of directions, 90 to 115 words per minute. A more recent study by Miller [9] found that there was no significant difference in learning when technical material of about 1000 words in length was delivered by tape recorder to 927 Air Force recruits at the rates of 95, 125, and 165 words per minute.

From transcribed copies of the program which the author prepared, as indicated in the above paragraphs, twelve tapes were made--one for each chapter and for each version. These tapes were produced by a person skilled in this area. He had had approximately fifteen years of engineering and broadcasting experience. They were prepared on superior equipment in a sound proof studio. Before these tapes were duplicated they were auditioned by the author and necessary corrections were introduced.

The time of each tape is given in Table 3.

At the conclusion of each frame a tone sounded. This served two purposes: first, the tone indicated to the student that it was time for him to answer the question or to complete the sentence, as the case might be; and second, the tone stopped the specially adapted tape recorder (Appendix K).

TABLE 3

TIMES (IN MINUTES) OF THE AUDIO TAPES

Chapter	Second Version	Third Version
One	20	22
Two	26	31
Three	21	27
Four	19	21
Five	30	40
Six	16	22

Preparation of the Attitude Questionnaire

A questionnaire designed to determine the attitude of the student toward the method of instruction was written especially for this study. This questionnaire (Appendix F) followed the format of a questionnaire, titled Attitude Toward Method of Instruction which was developed by Frank R. Hartman at The Pennsylvania State University [4].

CHAPTER III

DESCRIPTION OF THE STUDY

Introduction

This study was designed to determine whether or not there was a significant difference in learning when the programed unit "Systems of Numeration" was presented by the three different instructional methods:

> Method I.--The programed unit was presented visually--i. e., the student studied the program by reading it.

No extra material or equipment was needed. The students in this group were considered to be the control group. This method will be referred to as the programed text method. The programed material studied by the subjects in this method is given in the top left position in Appendix J.

> Method II.--The programed unit was presented partly aurally and partly visually--i. e., the student studied the program by listening to part of it and by reading part of it. Only when a new rule or algorithm was presented were both reading and listening employed simultaneously.

It must be emphasized that the students participating in this method were exposed to exactly the same program that was presented entirely visually in the programed text method. The programed material studied by the subjects in this method is given in the bottom left position in Appendix J.

The students in this method were equipped with individual ear pieces and electrical control boxes (Appendix K) designed so that they

could control the speed at which they studied the program and listened to the tape. No more than six students--generally fewer than five--studied concurrently. (Whenever it was possible these students were grouped homogeneously with respect to total raw score on the School and College Ability Test.[1]) That is, this small group was equipped with a specially adapted tape recorder which stopped automatically at the end of each frame. After each student completed a frame and checked his answer, he would press the button on his control box. When all buttons had been pressed, the tape recorder resumed delivery of the aural part of the next frame. Thus, in effect, the students were paced by the slowest student in their group.

This method will be referred to as the audio-supplemented programed text method.

> Method III.--The programed unit was presented almost completely aurally--i. e., the student studied the program by listening to most of it and by reading only enough to master notation and form.

Again, the students participating in this method were exposed to exactly the same program that was presented entirely visually in the programed text method. The programed material studied by the subjects in this method is given in the top right position in Appendix J.

As in the audio-supplemented programed text method, the students were equipped with individual ear pieces and control boxes and followed the same procedure as that followed in that method. This method will be called the audio-programed text method.

Each student in all three methods was given a small notebook in which he could record any notes, or examples, as he studied [6].

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[1] Educational Testing Service, Princeton, N. J.

Experimental Design

The design used for this experiment was a treatments x levels design of analysis of variance. The three treatments were the three instructional methods. The four levels were determined by the raw scores the subjects obtained on the School and College Ability Test. These levels were: high verbal--high quantitative, high verbal--low quantitative, low verbal--high quantitative, and low verbal--low quantitative. Within each level the subjects were randomly assigned to one of the three treatment groups.

Analysis of covariance was used to determine if the covariants, reading level and listening comprehension, affected the results obtained in the treatments x levels design.

The Wilcoxon Rank Sum Test was used to evaluate the attitude questionnaire.

The correlation of the covariants with each method of instruction was determined.

Subjects

During the trimester preceding the actual experiment, arrangements were made with the Department of Mathematics for obtaining four sections of the course entitled "Basic Mathematics for General Education." With the exception of those taking, or exempting, the course entitled "Integrated Algebra and Trigonometry," the former course is required of all students in the Division of Basic Studies at The Florida State University. These four sections, sections numbered 8, 11, 12 and 18, were chosen from twenty-one sections and were selected on the basis of their meeting three days a week instead of two, and of the size of the class (estimated

to be approximately thirty-five students). Each of the sections was taught during the afternoon.

In order that the unit "Systems of Numeration" be taught in the regular sequence of topics, the specific week the experiment was conducted was prescribed by the Department of Mathematics. (This was to follow the topic of exponents.) It was agreed that approximately eight hours of participation would be required of each student. This replaced three regular class meetings and the time each student would normally spend in preparation for this course during one week.

As soon as it was determined who the instructors for these classes would be, the author met with them, explained the experiment to them and asked their support and cooperation. It was agreed that nothing would be said about the experiment to the students at that time, nor would any knowledge of numeration systems be imparted to them in their regular classes.

The Pretest

The author also gave these instructors sufficient copies of a pretest, or inventory (Appendix C), devised to determine the amount of knowledge concerning numeration systems each student possessed prior to the experiment. The majority of students in these four classes took this test during the first class meeting. Those who registered late took the test as soon as it was possible after they began attending class.

The pretest given these students contained twenty-two questions concerning numeration systems, interspersed among twenty-eight questions concerning basic facts they should have known about arithmetic. The students were given approximately thirty minutes to complete the test.

As indicated in the instructions given them, they were to omit any problems they did not know or could not work.

It was determined that without knowledge of numeration systems, correct answers to five of the twenty-two problems (problems numbered 8, 23, 27, 39, and 40) could be obtained by generalization or guessing. There were only two students who were able to answer as many as six of the remaining problems; there were only two other students able to answer three of these; and there was only one other student able to answer two of these. After studying the pretests of the students, one of the students was eliminated from the experiment--this being one of the two able to answer as many as six of the remaining seventeen problems. The other one was not eliminated because the six problems she answered were all of the same type and not as comprehensive as the former student's answers.

It should be noted that the enrollment in these four sections was not as great as expected; it varied from 14 to 32 students.

Randomization of Subjects

Because the initial assignment to classes of students is done on a random basis, it was assumed that the four sections selected to participate in this study were representative of all classes in the population sampled. It was further assumed that the students in these sections were representative of the 769 students enrolled in these classes during the trimester in which this study was conducted.

As soon as complete rolls of these four sections were obtained, raw scores on the quantitative and on the verbal parts of the School and College Ability Test were obtained for each student who had taken this test prior to his enrollment in The Florida State University. It was

found, however, that ten students, for varied reasons, did not have these scores available.

The median for each of these two sets of scores was obtained. It was found to be between 37 and 38 for the verbal part, and to be between 34 and 35 for the quantitative part. It is interesting to note the percentile bands for these raw scores as given in Table 4.

TABLE 4

PERCENTILE BANDS FOR CERTAIN SCAT RAW SCORES

Raw Score	Percentile Band[a]
Verbal	
37	54 - 75
38	60 - 78
Quantitative	
34	45 - 68
35	48 - 71

[a]These are national norms for college freshmen, and are not based on sex.

Thus the four levels of ability were determined as given in Table 5.

The ninety-seven students available to be used in this experiment were thus partitioned into the four levels of ability as follows: HV-HQ 25 students, HV-LQ 24 students, LV-HQ 25 students, and LV-LQ 23 students.

The students in each level were then alphabetized by their last name and assigned numbers from a table of random numbers. Thus within each ability level the students were randomized across the three instructional methods. Of these ninety-seven students three failed to attend any

session and three failed to get started in the method to which they were assigned. Thus ninety-one subjects were used in the experiment.

TABLE 5

DEFINITION OF ABILITY LEVELS

Level	Raw Score	
	Verbal	Quantitative
High verbal-- high quantitative (HV-HQ)	38 and above	35 and above
High verbal-- low quantitative (HV-LQ)	38 and above	34 and below
Low verbal-- high quantitative (LV-HQ)	37 and below	35 and above
Low verbal-- low quantitative (LV-LQ)	37 and below	34 and below

Tests Given to Determine Interacting Factors

It was felt that tests should be given to the subjects in order to determine the variations in innate listening comprehension and innate reading comprehension. Two standardized tests, which were well reputed and which could be administered within a regular class period, were selected. These tests were: (1) The Brown Carlsen Listening Comprehension Test--Form AM,[1] and (2) The Davis Reading Test--Form 1A.[2]

The aural part of the Brown Carlsen Listening Comprehension Test was presented by the same individual who presented the aural part of the program. This was taped so that no variation could occur in the

[1] Harcourt, Brace, and World, Inc., New York, N. Y.

[2] The Psychological Corporation, New York, N. Y.

presentation of this test to the students who took it during their regular class meeting on the first day of the experiment. The same person also administered the test to the four classes, each of which met in the same room.

At this time the students were also told by means of a letter (Appendix D) that they would be required to participate in this experiment and asked to indicate when they could participate by signing a paper which gave the hours and locations of the experiment (Appendix D). They were also told, in writing, to which group (cell) they belonged. No information about the nature of the experiment was given, however.

The second test, The Davis Reading Test, was given to the students approximately twelve days after the experiment.

Other Controls

Care was also taken to determine whether or not any of the subjects had a hearing difficulty. This was done by consulting with infirmary personnel and the four regular instructors. No exceptional cases were found and no student mentioned any trouble of this kind during the experiment. There were no foreign students in these sections.

Description of the Population and of the Sample

Although students from all classes, freshman through senior, may take the course, "Basic Mathematics for General Education," the majority are freshmen and sophomores. Students are placed in these classes because they failed to achieve a required score on a test, Algebra II,[1] given by the Department of Mathematics. Many of the upperclassmen in these classes

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[1] Educational Testing Service, Princeton, N. J.

are transfers from other institutions. The population generally represents the lower 47 per cent of all students taking the required test. Usually, students in these classes intend to major in areas other than those of mathematics and science.

The sample of 91 students from this population of 769 students, who took this course during the fall of 1964, is assumed to be representative of the entire population. Table 6 exhibits the characteristics of this sample with respect to age, sex and class.

The Experiment

The experiment was conducted the week of October 19, 1964. As indicated earlier, this was the week prescribed by the Department of Mathematics. In one respect, this proved to be an unfortunate decision, as it was the week of midterm examinations for most of the students involved in the experiment. They felt this was an unfair imposition on them. Possibly the extra tension which the subjects were under accounted for some of the irregularities which occurred on the part of seven students.

The experiment was conducted continuously from 12:40 p. m. until 10:00 p. m. the first day, and from 8:00 a. m. until 10:00 p. m. each of the last four days. The students were allowed to come at any time which was convenient for them within the framework of the designated starting times. Some students came six separate times to study the six chapters; some stayed and studied more than one chapter; one waited until the very last afternoon and studied all six chapters--with only a break for dinner. Most of the students studied either one or two chapters at a sitting. In a very few cases it was necessary for a student to leave before

completing the chapter on which he was working and to resume the study during his next study period. In a very few cases it was also necessary for a student to return later, because of a conflict of schedule, to take a test on a particular chapter he had studied. Since all the students were essentially self-paced, it was not felt that any of these factors affected the results of the study.

TABLE 6

CHARACTERISTICS OF THE SAMPLE WITH RESPECT TO AGE, SEX, AND CLASS

Level	Age (in years)								Sex		Class			
	18	19	20	21	22	23	24	25	M	F	F	S	J	Sr
Method I														
HV-HQ	3	4							1	6	5	2		
HV-LQ	4	3					1		3	5	5	2	1	
LV-HQ	3	3	1	1					6	2	4	3		1
LV-LQ	2	2	2	1		1			3	5	3	3	1	1
Total	12	12	3	2		1	1		13	18	17	10	2	2
Method II														
HV-HQ		6	1						3	4	3	4		
HV-LQ	1	2	4	1					4	4	3	4	1	
LV-HQ	5	3	1						7	2	8	1		
LV-LQ	2	2	3						2	5	2	3	2	
Total	8	13	9	1					15	15	16	12	3	
Method III														
HV-HQ	4	2				1	1		2	6	6	2		
HV-LQ	4	1		1			1			7	5	2		
LV-HQ	4	2				1			5	2	5	1		1
LV-LQ	4	1	2						4	3	6	1		
Total	16	6	2	1		2	2		11	18	22	6		1
Total														
HV-HQ	7	12	1			1	1		6	16	14	8		
HV-LQ	9	6	4	2			1	1	7	16	13	8	2	
LV-HQ	12	8	2	1		1			18	6	17	5		2
LV-LQ	8	5	7	1			1		9	13	11	7	3	1
Total	36	31	14	4		2	3	1	40	51	55	28	5	3

It must be noted that machine trouble did occur in some instances. In each case this was remedied as soon as possible since the engineer who designed the machines was present at all times. In one instance one subject in the audio-supplemented programed text method, the HV-HQ level, failed to read his instructions (Appendix E) carefully, and did not notify the person administering the study that his machine was not stopping at the conclusion of each frame in the first chapter. He stated that he was able to keep up in most instances and did not feel he was hindered in his study; with the exception of the multiple-blank frames. It was also observed that in one instance it was necessary to remove one subject from the audio-supplemented method during the study of Chapter Two. Although she had no trouble with this method while studying Chapter One, she was very nervous when she took the second chapter and felt she was holding her group back too often. This increased her agitation. There were two cases of a tape breaking during the delivery of the aural part of the program. This was remedied immediately. Because of the various irregularities in the operation of machines, it was not possible to obtain a true and accurate indication of the average time spent by the subjects on each chapter. One individual (LV-LQ) in the programed text method said that he spent as much as two hours on a chapter. In no case did anyone in the two experimental groups spend nearly that long on any chapter--including time required to remedy machine trouble. It was generally observed, however, that the students in the experimental groups spent a little longer than those in the control group.

There were four specially adapted tape recorders used in the experiment. Since the students came at their own convenience, it was not

frequently possible to group the students homogeneously by total raw score on the School and College Ability Test. It was observed, however, that this would not have been a satisfactory scheme for grouping. The student with the highest total raw score in the audio-supplemented programed text method (HV-HQ) actually was the slowest student in her group. In other cases, students grouped randomly with respect to total raw score were nearly synchronized in the speed at which they studied and no one was required to wait.

It must be noted also that there were two students (LV-HQ) in the audio-supplemented programed text method who, in spite of repeated requests from the author, simply disregarded a large part of the aural portion of the program and studied only the second version of the programed text. It is believed that this action was prompted by their impatience in waiting for the slower students in their study group.

The students in each group were asked not to turn back and restudy frames they had already completed. This was controlled in one way by giving only one chapter at a time to a subject. He returned the completed chapter and his notebook before being given the criterion test for that chapter. Rigorous control of this was not possible within each chapter, however. Yet, it was not observed that the practice of turning back was engaged in to any great extent.

In addition to the students' being essentially self-paced in each of the three instructional methods, they were given unlimited time for the completion of each criterion test.

All three instructional methods were carried on simultaneously in the same room. Students were directed to sit in certain assigned

rows in order to take a particular chapter. Seven of the ninety-one students failed to follow these instructions. Whenever they first made this mistake, it was necessary to discard their data for that and subsequent chapters. One subject switched methods a total of three times in the experiment. When asked about this, he said that he did not realize there were different groups using the machines, hence he did not see the necessity of following directions. It was thought that curiosity must have led some in the control group to "sample" the machine method--especially on the last chapter. Because the author did not know these subjects, it was impossible to control this factor.

For various reasons, seven additional students failed to finish all six chapters. In each case these students would have been absent from their regular class meeting, or meetings, also. Participation in an out-of-town football game, previous out-of-town appointments, illness, or social functions elsewhere accounted for these absences.

It is interesting to note that none of these "lost" subjects were in the HV-HQ level of ability. They were fairly well distributed among seven of the remaining nine cells; hence it is felt that the assumption that the method of instruction did not interact with the cause of the missing data is justified.

The Attitude Questionnaire (Appendix F) was administered before Chapter Five. It was felt that no variation in the attitude of a subject would occur between this point and the conclusion of the study. Furthermore, with respect to timing, it was much easier to schedule the questionnaire at this time than after the completion of the comprehensive criterion test.

CHAPTER IV

ANALYSIS OF DATA

Criterion Tests

The criterion tests (Appendix I) were administered to each subject as indicated in Chapter III. The scoring of these tests was done by the author. A perfect score on each of the tests was 100 points. In every case in which any partial credit was given a record was kept and similar answers were given the same partial credit.

A treatments x levels design of analysis of variance was used to evaluate the data obtained from the six criterion tests. The descriptions of the three treatments and of the four levels were given in Chapter III. The specific hypotheses tested were:

1. The population mean is the same for all treatments.
2. The differences among corresponding treatment population means are the same for all levels.

Seven separate analyses were made on the data: one on the scores for each of the six tests and one on the total scores. Because the number of subjects per cell varied, the mean for each of the twelve cells was obtained from the raw data (Appendix A) and used as the measure for that cell. These means, along with the standard deviations and the sample sizes, are given in Table 7.

Using these means as the only score per cell, the mean squares for treatments (MS_T), for levels (MS_L), and for the residual (treatments x levels) (MS_{TL}), were obtained for each chapter and for the total.

TABLE 7

MEANS, STANDARD DEVIATIONS, AND SAMPLE SIZES OF THE CELLS

Level	Method I			Method II			Method III		
	$\bar{X}$	SD	n	$\bar{X}$	SD	n	$\bar{X}$	SD	n
Chapter One									
HV-HQ	99.4	1.51[a]	7	94.3	7.95	7	94.6	9.93	8
HV-LQ	95.8	6.61	8	95.6	6.93	8	91.6	9.71	7
LV-HQ	92.1	10.25	8	92.8	6.42	9	88.0	13.08	7
LV-LQ	84.5	10.65	8	83.9	14.12	7	90.3	8.20	7
Chapter Two									
HV-HQ	86.4	10.95	7	83.3	11.03	7	78.3	24.12	8
HV-LQ	82.0	13.94	8	82.3	16.31	7	70.7	20.82	6
LV-HQ	84.0	16.04	8	91.4	6.37	9	77.5	12.93	6
LV-LQ	71.9	12.31	8	66.0	20.40	7	75.1	22.32	7
Chapter Three									
HV-HQ	94.6	7.46	7	92.3	8.30	7	89.6	19.91	8
HV-LQ	88.9	13.28	8	87.7	11.13	6	66.5	21.10	6
LV-HQ	93.9	7.18	8	79.1	20.52	8	81.5	14.25	6
LV-LQ	75.4	23.16	8	70.7	18.71	7	83.3	14.79	6
Chapter Four									
HV-HQ	93.3	4.72	7	91.7	5.88	7	89.5	8.23	8
HV-LQ	84.0	9.50	7	80.7	14.54	6	79.8	16.41	6
LV-HQ	86.6	8.42	8	85.4	4.72	8	80.0	16.02	6
LV-LQ	69.2	20.61	8	70.3	14.73	7	79.7	12.21	6
Chapter Five									
HV-HQ	95.3	6.55	7	95.6	9.69	7	99.5	1.41[a]	8
HV-LQ	97.1	3.08	7	77.5	22.98	6	92.0	9.32	6
LV-HQ	93.1	10.30	8	96.9	5.06	8	83.8	15.40	5
LV-LQ	76.4	32.78	8	78.4	18.50	7	87.7	9.81	6
Chapter Six									
HV-HQ	91.1	7.10	7	80.7	10.93	7	80.9	21.25	8
HV-LQ	83.7	6.06	6	67.2	16.20	6	67.5	13.95	6
LV-HQ	81.1	10.68	8	70.0	21.23	6	75.2	13.00	4
LV-LQ	58.3	20.42	7	59.0	17.22	7	68.0	11.11	5
Total									
HV-HQ	560	24.78	7	538	35.60	7	532	77.09	8
HV-LQ	530	30.70	6	488	52.55	6	467	71.64	6
LV-HQ	531	50.86	8	513	38.46	6	487	70.49	4
LV-LQ	432	106.61	7	428	78.92	7	498	29.16	5

[a]The low SD in these two cases is accounted for by the fact that the scores for these chapters were truncated at the maximum and the range of scores was only four points.

From the original data (Appendix A), the mean square for within cells (MS_W), was computed for each chapter and for the total using the formula:

$$MS_W = \frac{\sum_{i=1}^{4}\sum_{j=1}^{3}(n_{ij} - 1)(s_{ij})^2}{\sum_{i=1}^{4}\sum_{j=1}^{3}(n_{ij} - 1)} + \frac{n}{12}$$

where i indicates the level, j indicates the treatment, n_{ij} indicates the number of subjects for cell ij, s_{ij} indicates the standard deviation of the observations for cell ij, and N indicates the total number of subjects for that particular collection of observations.

This is essentially the method presented by Winer [19, p.242] except he has used as a divisor the harmonic mean of the cell frequencies, $\bar{n}_{ij}$, instead of the N/12 used above. For example, for Chapter One $\bar{n}_{ij} = 7.5318$, and $N/12 = 7.5833$.

The results of these analyses are given in Table 8.

TABLE 8

ANALYSIS OF VARIANCE OF TEST SCORES FOR EACH OF THE CHAPTERS AND FOR THE TOTAL

Source	SS	df	MS	F	p
		Chapter One			
Levels	169.629	3	56.543	4.9974	<.01
Treatments	7.062	2	3.531	.3121	>.05
Residual	58.978	6	9.830	.8688	>.05
Within Cells		79	11.314		
		Chapter Two			
Levels	317.869	3	105.956	2.9299	<.05
Treatments	81.245	2	40.622	1.1233	>.05
Residual	178.968	6	29.828	.8248	>.05
Within Cells		76	36.164		

TABLE 8--Continued

Source	SS	df	MS	F	p
		Chapter Three			
Levels	397.136	3	132.379	3.6252	<.05
Treatments	135.485	2	67.742	1.8551	>.05
Residual	401.862	6	66.977	1.8342	>.05
Within Cells		73	36.516		
		Chapter Four			
Levels	519.710	3	173.237	8.1443	<.01
Treatments	3.552	2	1.776	.0835	>.05
Residual	104.835	6	17.472	.8214	>.05
Within Cells		72	21.271		
		Chapter Five			
Levels	395.729	3	131.910	4.0762	<.01
Treatments	33.052	2	16.526	.5107	>.05
Residual	348.308	6	58.051	1.7939	>.05
Within Cells		71	32.361		
		Chapter Six			
Levels	771.269	3	257.090	7.1530	<.01
Treatments	176.512	2	88.256	2.4556	>.05
Residual	192.708	6	32.188	.8936	>.05
Within Cells		65	35.941		
		Total			
Levels	12,748.667	3	4,249.556	7.1893	<.01
Treatments	1,037.167	2	518.583	.8773	>.05
Residual	5,524.833	6	920.806	1.5578	>.05
Within Cells		65	591.087		

The F_{max} test, or Hartley's test, was employed in each of the above analyses and it was determined that the assumption of homogeneity of variance was valid. This is indicated in Table 9. The standard error of the mean is used as the statistic in the ratio for F_{max}, as given in this table.

It was, therefore, necessary to accept the two null hypotheses under consideration for each of the seven analyses. This is interpreted to mean that, for the students participating in this experiment, the

degree of aural stimulation in this programed auto-instructional mathematical material (Appendix J) does not affect, significantly, the learning process as demonstrated by performance on the criterion tests. Furthermore, the degree of aural stimulation does not affect students of one ability level differently from those of another ability level.

The differences in means are significant at the .05 level of significance for the four ability levels in each of the analyses. This, however, is not surprising. (It can be pointed out that by using a treatments x levels design, much more accurate results are obtained since this variance is excluded from the error mean square.)

TABLE 9

SUMMARY OF TESTS FOR HOMOGENEITY OF VARIANCE

Chapter	Observed F_{max}	Tabled F_{max} Statistic at .05 level
One	9.3684	$F_{max}(12,7) = 15.9$
Two	4.0236	$F_{max}(12,7) = 15.9$
Three	3.3898	$F_{max}(12,7) = 15.9$
Four	4.3653	$F_{max}(12,6) = 20.9$
Five	9.9913[a]	$F_{max}(11,6) = 19.7$
Six	3.5101	$F_{max}(12,6) = 20.9$
Total	4.3055	$F_{max}(12,6) = 20.9$

[a]The extremely low variance in cell 31 was disregarded in evaluating the homogeneity of variance in this chapter.

Analysis of the Effect of the Covariants of Listening Comprehension and Reading Level

Analysis of covariance was applied to the total scores at each of the four levels to evaluate the difference between adjusted means. They were adjusted, first, with respect to listening comprehension, and

second, with respect to reading level. The standardized tests used to obtain these covariant scores are discussed in Chapter III.

Again it was necessary to accept, in each instance, the null hypothesis:

> The mean of the adjusted scores is the same for all treatment populations.

This is interpreted to mean that, at each of the four ability levels and in spite of the differences in the special abilities as measured by the tests for listening comprehension and for reading level, the degree of aural stimulation in the programed auto-instructional mathematical material studied by the subjects in this experiment does not affect, in any significant way, the learning process as demonstrated by performance on the criterion tests.

A summary of the covariance analyses for the total scores is given in Tables 10 and 11.

TABLE 10

ANALYSIS OF COVARIANCE OF TOTAL TEST SCORES ADJUSTED WITH RESPECT TO LISTENING COMPREHENSION FOR EACH ABILITY LEVEL

Source	SS'	df	MS'	F	p
		HV-HQ			
Treatments	2,324	2	1,162	.3994	>.05
Error	52,357	18	2,909		
		HV-LQ			
Treatments	9,281	2	4,640	1.6824	>.05
Error	38,608	14	2,758		
		LV-HQ			
Treatments	5,278	2	2,639	.9170	>.05
Error	40,294	14	2,878		
		LV-LQ			
Treatments	17,272	2	8,636	1.1905	>.05
Error	108,811	15	7,254		

TABLE 11
ANALYSIS OF COVARIANCE OF TOTAL TEST SCORES ADJUSTED WITH RESPECT TO READING LEVEL FOR EACH ABILITY LEVEL

Source	SS'	df	MS'	F	p
		HV-HQ			
Treatments	7,253	2	3,626	1.5014	>.05
Error	43,465	18	2,415		
		HV-LQ			
Treatments	8,960	2	4,480	1.4299	>.05
Error	43,859	14	3,133		
		LV-HQ			
Treatments	5,241	2	2,620	.9097	>.05
Error	40,318	14	2,880		
		LV-LQ			
Treatments	21,052	2	10,526	2.0819	>.05
Error	75,847	15	5,056		

The mean of the deviation from the mean of the total scores, $\bar{y}$, and the adjusted mean of the deviation from the mean of the total scores, $\bar{y}'$, are given in Table 12 for each level and for each treatment. No major variations with respect to the order of these means and these adjusted means are observed.

TABLE 12

MEANS, AND ADJUSTED MEANS, OF THE DEVIATIONS FROM THE MEAN OF THE TOTAL TEST SCORES

Level	Method I		II		III	
	$\bar{y}$	$\bar{y}'$	$\bar{y}$	$\bar{y}'$	$\bar{y}$	$\bar{y}'$
	Adjusted with Respect to Listening Comprehension					
HV-HQ	17.14	15.40	- 5.14	- 5.72	-10.62	- 8.59
HV-LQ	35.33	29.37	- 7.50	- 2.65	-28.00	-26.91
LV-HQ	15.88	15.57	- 1.25	.03	-28.00	-29.50
LV-LQ	-15.00	-15.92	-19.71	-19.85	50.40	50.48

TABLE 12--Continued

Level	Method I $\bar{y}$	I $\bar{y}'$	II $\bar{y}$	II $\bar{y}'$	III $\bar{y}$	III $\bar{y}'$
	Adjusted with Respect to Reading Level					
HV-HQ	17.14	28.12	- 5.14	-11.37	-10.62	-14.74
HV-LQ	35.33	33.04	- 7.50	- 7.94	-2[illegible].00	-25.27
LV-HQ	15.88	16.45	- 1.25	- 2.21	-28.00	-27.71
LV-LQ	-16.00	-14.08	-19.71	-25.20	50.40	55.42

Correlation of Criterion Scores with Listening Comprehension Scores and with Reading Level Scores

It is interesting to observe the relationships between the total scores on the criterion tests and the percentile scores on the Brown Carlsen Listening Comprehension Test, and between these total scores and the percentile scores on the Davis Reading Test. These correlations are given for each instructional method in Table 13.

TABLE 13

CORRELATIONS OF TOTAL TEST SCORES WITH LISTENING AND WITH READING SCORES

Method	Listening Comprehension	Reading Level
I	.326	.658
II	.336	.446
III	- .149	.341

Thus a relatively high correlation exists between a student's reading ability, as measured by this test, and his performance on the criterion tests (Appendix I) when the method of instruction required a great deal of reading. Furthermore, these data point out that the less reading--and the more listening--this program required, the less a

tudent's performance depended upon reading skill. This confirms observations by educators [15, 3] that reading ability plays a large role in the success a student experiences in studying conventional (non-audio) programed material.

Corresponding conclusions cannot be made with reference to listening comprehension, however. It seems that listening comprehension, as measured by the Brown Carlsen Listening Comprehension Test, plays a rather insignificant role, even though a great deal of listening may be required.

Attitude Questionnaire

The Wilcoxon Rank Sum Test was used to evaluate the data obtained on the Attitude Questionnaire (Appendix F). The null hypotheses under consideration were:

1. The population mean is the same for each of the three instructional methods.
2. The population mean is the same for each of the three instructional methods at each ability level.

The following method of scoring was used for the attitude questionnaire. For each question, except the intensity questions numbered 7 and 14, a grade of five points was assigned if the student marked "a," a grade of four points if the student marked "b," three if "c," two if "d," and one if "e." Thus for the questionnaire the maximum number of points is 90 and the minimum is 18. If a student failed to mark any of the letters it was assumed he was undecided and he was given three points for that question. A neutral score is 54. A high score represented a positive attitude toward the method of instruction; a low score, a negative attitude.

The intensity questions were not scored because research has pointed out that there is a great deal of error in this type of question [4, p. 57]. It might be pointed out, however, that the majority of students answered either "a" or "b" to these questions. Of the 83 subjects, seven answered "c" and six answered "d" on question 7; seven answered "c" and two answered "d" on question 14.

It was necessary to accept the first hypothesis at the .05 level of significance (two-sided). This is interpreted to mean that, for the students participating in this experiment, there is no significant difference in their attitude toward the method of instruction for the three treatments. The attitude of the students in the experimental treatments was as positive as the attitude of those in the control group. The comparison of the results obtained on the questionnaire is given in Table 14.

TABLE 14

THE WILCOXON RANK SUM TEST ANALYSIS OF ATTITUDE QUESTIONNAIRE SCORES

Comparison of Methods	M	N	T	T_l	T_u
I and II	28	30	932	700	952
I and III	25	30	721	584	816
II and III	25	28	608	565	785

Hence $T_l < T < T_u$ in each case.

The differences in variability were also studied for each of the three methods. It was found that the difference in variability between

any two methods is not significant at the .05 level (two-aided). This analysis is presented in Table 15.

TABLE 15

THE WILCOXON RANK SUM TEST ANALYSIS OF THE VARIABILITY OF ATTITUDE QUESTIONNAIRE SCORES

Comparison of Methods	M	N	T	T_l	T_u
I and II	28	30	858	700	952
I and III	25	30	684	584	816
II and III	25	28	655	565	785

Hence $T_l < T < T_u$ in each case.

It was also necessary to accept the second hypothesis at the .05 level (two-sided). This is interpreted to mean that, for the students participating in this experiment, there is no significant difference at each ability level in their attitude toward the method of instruction for the three treatments. Table 16 points this out for each ability level.

TABLE 16

THE WILCOXON RANK SUM TEST ANALYSIS OF ATTITUDE QUESTIONNAIRE SCORES AT EACH ABILITY LEVEL

Level	M	N	T	T_l	T_u
Comparison of Methods I and II					
HV-HQ	7	7	52.5	37	68
HV-LQ	6	7	54.0	28	56
LV-HQ	8	8	72.0	49	87
LV-LQ	7	8	60.5	39	73

Hence $T_l < T < T_u$ in each case.

TABLE 16--Continued

Level	M	N	T	T_1	T_u
		Comparison of Methods I and III			
HV-HQ	7	8	56.0	39	73
HV-LQ	6	7	44.5	28	56
LV-HQ	5	8	33.0	21	49
LV-LQ	6	8	46.0	29	61
	Hence $T_1 < T < T_u$ in each case.				
		Comparison of Methods II and III			
HV-HQ	7	8	56.0	39	73
HV-LQ	6	6	32.0	26	52
LV-HQ	5	8	31.0	21	49
LV-LQ	6	7	40.0	28	56
	Hence $T_1 < T < T_u$ in each case.				

The corresponding study of variability yielded the results in Table 17.

TABLE 17

THE WILCOXON RANK SUM TEST ANALYSIS OF THE VARIABILITY OF ATTITUDE QUESTIONNAIRE SCORES AT EACH ABILITY LEVEL

Level	M	N	T	T_1	T_u
		Comparison of Methods I and II			
HV-HQ	7	7	51.5	37	68
HV-LQ	6	7	35.0	28	56
LV-HQ	8	8	76.0	49	87
LV-LQ	7	8	50.5	39	73
	Hence $T_1 < T < T_u$ in each case.				
		Comparison of Methods I and III			
HV-HQ	7	8	57.0	39	73
HV-LQ	6	7	41.8	28	56
LV-HQ	5	8	16.0	21	49
LV-LQ	6	8	52.0	29	61
	Hence $T_1 < T < T_u$ in three of the above cases, but $T < T_1$ for the LV-HQ ability level.				

TABLE 17--Continued

Level	M	N	T	T_l	T_u
Comparison of Methods II and III					
HV-HQ	7	8	40.7	39	73
HV-LQ	6	6	34.0	26	52
LV-HQ	5	8	27.0	21	49
LV-LQ	6	7	53.0	28	56

Hence $T_l < T < T_u$ in each case.

Thus the only place where the difference in variability is significant at the .05 level (two-sided) is in the comparison of Methods I and III at the LV-HQ level. This is also significant at the .01 level (two-sided) since $T_l = 18$ and $T_u = 52$. This is interpreted to mean that the variability of the scores in Method I is significantly less than the variability of the scores in Method III for this ability level. It must be pointed out, however, that this significance is influenced by one extreme score in Method III. If this score, 45, is omitted then $M = 4$, $N = 8$, $T = 26.0$, $T_l = 14$, $T_u = 38$, and $T_l < T < T_u$. Thus the difference in variability is no longer significant at the .05 level (two-sided).

Several unsolicited comments were made on these questionnaires. These are given in Appendix H. A record of the incidence of responses to each of the twenty questions was also kept (Appendix G). The grand mean, the various means for each cell, each treatment, and each level, are given in Table 18.

It is pertinent to this study to observe the responses to question 10 concerning correct pronunciation:

10. After studying the program by the method that I used, I feel that

    (a) I could speak to my teacher about this subject and not be worried about using incorrect pronunciation.

    (b) I might slip up once in a while, but I would pronounce most of the words correctly.

    (c) don't know or undecided.

    (d) I would hesitate to talk to my teacher, but I know I can pronounce as many words correctly as any other person who took the program.

    (e) I would hesitate to talk to anyone about what I have learned for fear I would not use correct pronunciation.

There seemed to be no marked feeling of a handicap in this respect by the control group, nor a pronounced feeling of confidence by the experimental groups.

TABLE 18

MEANS OF ATTITUDE QUESTIONNAIRE SCORES

Level	Method I	Method II	Method III	Total
HV-HQ	69.86	69.86	70.12	69.95
HV-LQ	60.43	75.17	64.50	66.37
LV-HQ	67.83	70.25	65.20	68.14
LV-LQ	67.38	70.29	69.00	68.80
Total	66.47	71.21	67.52	68.39

Questions 15 and 16 were also intended to serve as a gauge to "measure" enthusiasm and motivation.

15. Suppose you had a younger brother, or sister, in high school, would you want to

    (a) try to teach him what you have learned in this unit?

    (b) mention you had studied numeration systems, but make no further comment?

    (c) ignore the subject if it came up?

    (d) try to change the topic of conversation?

    (e) leave the room to avoid talking about it?

16. Having studied this program, I feel that
    (a) I would like to learn more about numeration systems.
    (b) I might check a book on numeration systems out of the library, but fail to read it.
    (c) don't know or undecided.
    (d) I doubt if I would ever actually check out a book on numeration systems though I might <u>think</u> about doing it.
    (e) once this is over, no more <u>numeration systems</u> for me!

It seems from the results that most of the students would like to share the knowledge they had gleaned from this study, but only a little more than a third of them indicated they would be motivated to learn more about numeration systems.

The responses to question 17, concerning the humor in the program, were interesting.

17. I found the humor in this program
    (a) quite entertaining--tended to keep the program from being so dry.
    (b) tended to make the program more personal.
    (c) don't know or undecided.
    (d) immature and silly.
    (e) ---what humor?!

It was observed by the author that several students <u>erased</u> their initial response, "e," and then circled either "a" or "b." Twenty-eight students admitted they had not recognized any humor.

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The results of each of the analyses discussed in Chapter IV indicate that the means of each of the treatment groups at each of the ability levels did not differ significantly at the .05 level. Thus, one may conclude that the two experimental groups performed at least as well as the control group and that the effects of the three treatments were essentially equivalent.

The results obtained by analysis of covariance also indicated that the two covariants, listening and reading, did not greatly affect the performance of the students. Of these two abilities, however, reading had the greater effect. As the amount of material to be read became less, reading skill became less important.

The relationships between the mean scores of the criterion tests for the treatments at each ability level and the relationships between these scores for the ability levels in each instructional method are illustrated by means of graphs (Appendix B).

The only group which scored consistently higher than the corresponding groups in that level was the group taught by the audio-programed text method in the LV-LQ level of ability. This seems to indicate that, although the differences between these means are not

statistically significant, the aural mode of presentation of the subject matter did help those who were weaker with respect to ability as indicated by the School and College Ability Test.

It was expected that the effect of ability, as determined by scores on the School and College Ability Test, would be important. As the results indicate, the differences between the means for levels of ability are significant at the .05 level in each analysis of variance presented in Chapter IV. It is not surprising, therefore, that the means for each of the treatment groups in the HV-HQ level were greater than the corresponding mean of any of the LV-LQ groups. No similar conclusions can be made concerning the means of any other pairing of levels, however.

From the analysis of the attitude questionnaire it may be concluded that the overall attitude of the students toward the method of instruction they received was favorable. The unfavorable remarks most noted were those concerning the inappropriateness of the scheduling of the experiment during the week of midterm examinations and the waiting on the part of the faster students in the experimental groups for those in their group who worked more slowly. Some of the students also expressed their dislike for being required to study the program in a particular place other than in their rooms where normally they studied their mathematics "after midnight."

The implications of the results of this research are many. The reproduction of taped programs on phonograph records can be done easily and economically. These records could serve many students who would only have to purchase the greatly abbreviated answer booklet. Thus the cost

to the student of the programed instruction could be greatly reduced. Students could study individually and, if they owned a phonograph, could study the program at home. This would be a distinct advantage especially in adult education. Those who did find the reading of the program very tedious would not be at so great a disadvantage.

These same records could also be used by blind students, and the accompanying Braille answer booklet would not be as expensive as a complete program in Braille.

Recommendations

The author is convinced that additional research in this area is needed. She feels that audio-programed instruction is definitely an aid in learning material of a quantitative nature for those who are weak in verbal and quantitative abilities. It might prove an even greater help in learning material of a non-quantitative nature for a much greater portion of students.

Had this experiment been free of mechanical difficulties and had individuals in the experimental groups always been combined so that no one would have long periods of time to wait while taking the program, possibly more significant results would have been demonstrated by these experimental groups in <u>all</u> of the ability levels.

These data also lead one to suspect that audio-complemented programed material may be of assistance in learning for the more able student when material involving references to tables <u>and</u> computation is taught.

Research needs to be done concerning externally-paced conditions versus self-paced conditions for audio-programed material. Research in

other areas, especially in those requiring a high verbal ability, may lead to more significant differences for those who are verbally weak than this study was able to demonstrate.

Research is needed in the area of audio-programed material at other age levels, where possible differences in reading ability are much greater. It would be interesting also to study the influence on learning by audio-programed instruction when various "voices" are used--e. g., a child's voice used with his contemporaries, as compared with an adult, authoritative voice.

Because of the voluminousness of the appendices pertaining to this research, only representative pages (frames) from the first chapter of the program (Appendix J) are included. Complete appendices are given in the dissertation, bearing the same title, by the author, which is on reference at The Robert Manning Strozier Library, Florida State University, Tallahassee, Florida.

The complete list of references is included at the end of this report.

(Page numbers listed in the Table of Contents and the List of Tables refer to those in the dissertation.)

ATTENTION!

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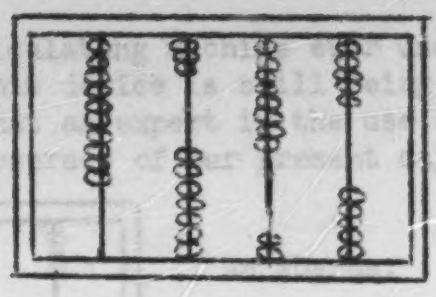
1)



An abacus

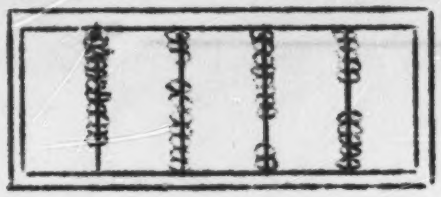
---

abacus

(From Chapter One.)

1)

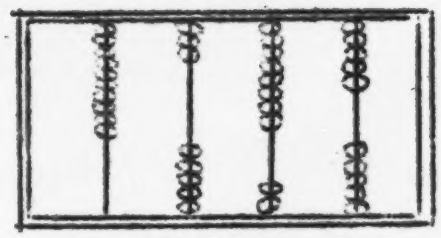
Perhaps the earliest calculating machine ever used by man was a device called the abacus. This device is still being used today in the Orient, and it is reported that an expert in the use of an abacus can compute with the speed and accuracy of our present day adding machines.



An abacus.

Such a calculating machine, which was used as long ago as 600 B. C. is called an _____.

1)



An abacus

Such a calculating machine, which was used as long ago as 600 B. C., is called an _____.

4)

Ten different symbols:

0, 1, 2, 3, 4, 5, 6, 7, 8, 9.

a _____ system.

decimal

(From Chapter One.)

4)

The reason we have chosen to begin our study with a decimal abacus is that the numeration system used in most parts of the world today is the <u>decimal</u> <u>system</u>--a system based on the <u>ten</u> different symbols:

0, 1, 2, 3, 4, 5, 6, 7, 8, 9.

A numeration system based on ten different symbols is called a _____ system.

4)

Ten different symbols:

0, 1, 2, 3, 4, 5, 6, 7, 8, 9.

A numeration system based on ten different symbols is called a _____ system.

And fourth: We learned how to write consecutive numerals in a given base.

Write the consecutive ternary (base three) numerals from 1_{three} to 100_{three}.

(Remember the only symbols in this system are 0, 1, and 2.)

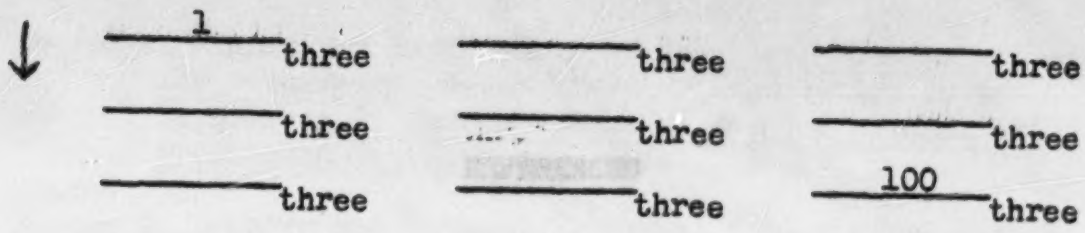
$\downarrow$ 1 three	three	three
three	three	three
three	three	100 three

44)

The consecutive ternary numerals from 1_{three} to 100_{three} are:

$\downarrow$ 1 three	three	three
three	three	three
three	three	100 three

44)



1_{three} 11_{three} 21_{three}

2_{three} 12_{three} 22_{three}

10_{three} 20_{three} 100_{three}

(From Chapter One.)

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